

A LINEAR POWER AMPLIFIER FOR AUSTRALIAN CONDITIONS

PART ONE

R. A. J. REYNOLDS, VK3AAR

Home brewing is becoming a lost art amongst the majority of Amateurs. This is not at all surprising, as the benefits of mass production have been extended to the area of Amateur Equipment, and the cost benefits of home brewing have been considerably eroded. However, modern commercial considerations have robbed the Amateur of the component supplies that he would like to home brew; recent developments at the Commercial level have yielded particular components that would greatly improve a home brew but are simply not available, and Commercial construction methods produce an article which is compact, attractive, and generally effective in operations.

There is little to encourage the Amateur to construct his own 160 through 10 Transceiver, or 2 metre SSB Kiddie phone. However there are many areas of Amateur endeavour that still inspire home brewing. The novel, the simple, the unavailable, and the financially unattractive items for example have many Amateurs reaching for the screwdriver and soldering iron.

How often do we hear the expression, "Yaesu FT101B through a home brew linear to a TH3 beam at 12 metres?" It would appear that more Amateurs turn their hand to building linears than any other major item.

THEORETICAL ASPECTS

The linear is a single stage device involving only a couple of dozen components, there are no critical adjustments, and there are considerable financial gains to be obtained, particularly if there is a junk box and a local surplus store that may be referred to for normally pricey items.

Over the years plenty of designs and construction descriptions have appeared for linear amplifiers for SSB service for varying numbers of bands and varying parts of the RF Spectrum. Probably the most popular linear configuration is the 80 through 10 grounded grid amplifier. But that is where the similarity ends. Depending on the design criteria there is a wild assortment of tube types, power supplies, efficiency targets, drive arrangements, to say nothing of size and shape.

It is an Engineering Fact that, given a set of design parameters, a number of designers will come up with the same number of different designs, controlled by their personal likes and dislikes. Hence the variations that we see in the published designs of linears. Thus, one designer's use of sweep tubes may be controlled by the desire to keep voltages low, whilst another's choice of tube may be controlled by a requirement of maximum circuit efficiency. However, the basic design steps are the same, once the overall requirements are stated.

Most linear amplifiers in the 10 to 80 metre configuration that are built in this country are based on the general designs that have been so regularly published in the USA. They fall into categories controlled by the type of tube used, and the power rating. The tube types are the sweep tube, usually 4 tubes in parallel, of the type designed for the horizontal sweep output stage of television sets; the Transmitting tube type where tubes were actually designed for good linearity in SSB ampli-

fier service, and the "available tube" type, where the tubes chosen are available at low cost from surplus sources. Most designs are around the 1 kW or 2 kW PEP input target and attempt to extract the highest efficiency, even at the expense of linearity in some cases.

Under the regulations in force in this country, the design parameters are somewhat different. Our rules say — *A3A or A3J emission, the peak envelope power of the Radio Frequency output, measured at the input to the antenna transmission line, shall not exceed 400 watts* — The rules then go on to define that the measurement method shall be by doubling the power measured when a two tone output is run into a matching resistive load under maximum linear transmitter output conditions. No reference to maximum input power, no reference to tube power capability, no reference to degree of linearity, no reference to average RF power output under speech conditions and no reference to effective radiated power from the Antenna.

A general result of this is that we are permitted to use as much power as we like to produce a clean 400 PEP output. There are two significant design parameters that result from this state of matters.

1. There is no necessity to specify a high efficiency, and hence high cost output tuning unit.
2. The grounded grid amplifier, which transfers some of the input driving power to the output, giving a higher overall output for a given DC input power to the anodes, loses some of its attraction.

With a couple of assumptions, we are now in a position to write down all of the requirements of a linear amplifier for 80 through 10 metres for SSB service under the rules in force in Australia, assuming that we wish to obtain the legal limit. The

biggest assumption that will be made is that most operators wish to use an exciter of the Collins KWM2 type, the unit that has inspired so many manufacturers in the 20 or so years since its first release. A second assumption will be that a nominally 50 to 70 ohm resistive output feed is required. Operators who wish to run open line will more than likely be considering an out-board ATU and may, within the rules, measure their power at the open wire line in any case. So, while we may consider variations to the fine details, the following is the general specification for a linear amplifier as outlined above.

Frequency coverage: 3.5 to 29.7 MHz covering at least the Amateur bands within the spectrum.

Excitation Power: Up to 100 watts PEP.

Output Power: 400 watts PEP in each of the Amateur Bands, as measured by the approved method.

Input impedance: 25 to 100 ohms resistive and within 2:1 SWR against 50 ohms if reactive.

Output impedance: As for the input.

Intermodulation products: As low as possible, say —30 dB.

Power Supply: 240 Volts $\pm$ 10% 50 Hz Single phase.

Complexity: The design to be kept as simple as possible.

Service of operation: Single Side Band, with or without RF speech processing.

Cost: To be kept low, but not at the expense of good design, convenience, or safety.

And before we go any further, *safety*. This subject has been mentioned many times in the discussion of linear amplifiers of this kind, but another mention is not out of place. The type of amplifier that we will be discussing will require a power supply at a potential of 1000 to 4000 volts with a steady state output current of amperes for a few seconds. Personal contact with the output of such a supply is almost certain to be lethal. You might be lucky and live through such an experience, but whilst I have heard of deaths from exposure to linear supplies in this voltage area, I have not heard of one survival. Higher voltages have been known to throw victims clear, usually with burns and physical injury, and a good many of us have been unfortunate enough to get across 600 volts or so, yet this class of potential that we will be considering is very final, and we will be considering more than care; we will be considering special precautions to avoid the possibility of contact with the high tension. QSOs might be possible with operators in an after life, but QSLs are impossible.

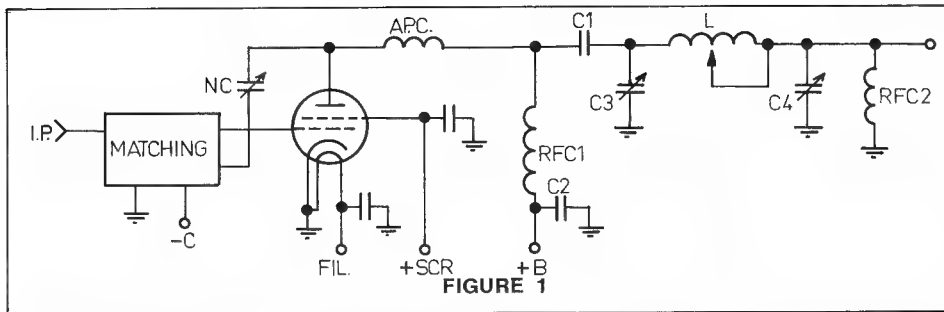


FIGURE 1

Jokes aside, we must all take a responsible attitude towards the handling of the high potentials present in this type of equipment. It is a rather good idea to have somebody with technical ability present when you first test such a supply. Never be too proud to call for aid, double checking is well worth the effort, and that helper may well own a safer EHT probe. During the construction part of this text, which will follow in a later issue, as I have already indicated, we will be discussing the fine details of insulation and component ratings.

Virtually all linear amplifiers used in the amateur service for SSB are single-ended using a Pi-coupler in the output. I have not attempted to consider other systems for this discussion, as the configuration as above appears at first glance to be considerably simpler than its nearest rival, and since this simple arrangement does give a satisfactory result, there seems little point in searching further.

At this point in the discussion, one or two general principles must be considered, and these principles are rather interdependent. So while it may appear to be a little out of place in the discussion, we will consider the type of tube that we might use.

The plate efficiency of most linear amplifiers is about 45%, and since the output coupling efficiency is going to be about 80% and a speech processed voice waveform about 50% duty cycle, it can be deduced that the anode dissipation in the final will be about 300 watts in a continuous duty mode. While some of us may have 'overs' lasting for hours, the ragchew voice waveform duty cycle tends to be somewhat lower. The general result is that we are looking for a total anode dissipation capability of something less than 300 watts. The question may be asked as to how much less. Since the tubes that individuals may wish to use are designed for varying classes of operation, there can be no general rule. Some tubes can take very high powers for a few seconds, or even minutes if they have heavy anodes with a high heat capacity, whilst others with light anodes can take little more over a period of a couple of minutes than they can in continuous duty.

The question of cathode capability also comes into the picture. Tube manufacturers do not design any more power into their cathodes than they need, and the power that can be extracted from a tube in a linear is rather closely tied to the filament or cathode power. It is interesting to note that there are moves within the

USA to limit the size of output amplifiers by placing a limit on the size of the heater! Whether the cathode is directly or indirectly heated also has a large bearing on the subject (ref. 'Ham Radio' June 1975, p.4). Whilst not much more than a guess, about 75 watts filament power for directly heated cathodes and about 25 watts in the indirectly heated case are going to be required. But don't the usual run of sweep tubes need about 70 watts or so to raise 400 W PEP?

Yes, but they need that sort of power for the TV service for which they were designed. In linear service they are run at a lower cathode utilization than can be extracted from tubes designed for RF service. So we get down to tube types and their comparison.

Fortunately, many constructors have done a good deal of the work for us and we only have to look at the published designs to establish a first guess as to what tube we want. But before we do it might be possible to ease the job by ruling out a number of the tubes that have been considered previously. While almost any tube could be used in our application, a tube that a manufacturer has designed expressly for linear service has one advantage as far as we are concerned. To find out the voltage, current, and drive requirements we need only look up the manufacturer's specification sheet. In this way we can design directly to ICAS conditions, or if we wish to be a bit conservative, we can use the published CCS conditions.

We should rule out the family of sweep tubes immediately, as well as the older style of RF tube designed for class C service. These tubes may of course be used to good effect, but there are problems which we could do well without. For example, some tetrodes exhibit what is known as Barkhausen oscillation, due to a negative plate characteristic, rather more than we would like. We have already

stated that we wish to operate at close to 30 MHz, so there is little point in considering tubes that require additional cooling, or to be run at reduced ratings, at higher frequencies. There is no need to choose a tube or tubes that can produce more power than we need. In addition, if we can do away with a couple of power supplies and noisy blowers, we would be moving a little more towards the simplicity requirement.

On the other hand it is quite likely that down in that junk box there are a couple of tubes that you have been saving for that 'home brew linear' that would not appear to be ideal. Of course you do not throw them away, for while they may not be ideal, may not deliver full power on 10, or may have to be run with more standing current than an ideal tube, they will give good service. But even 'disposals' 813s cost a lot of money these days, and are not much cheaper than a nice 4CX250 or 3-500Z. Now and again some of these latter tubes turn up in the surplus area, and quite usually at bargain prices. The newer tubes have yet another advantage. Their operating frequencies are rather higher than the wait time bottles. 813s and the like start to fold up at 30 to 60 MHz whilst the newer linear tubes, and particularly the smaller ones, run out to several hundreds of MHz.

There are several families of tubes that are well worth consideration. Perhaps the most popular would be the glass giant 5-pin tetrodes in the 4-125A class. These are available in anode dissipation ratings from 65 watts to over 1 kW. However, a word of warning. The 4-65A is not suitable for triode connection grounded grid service, as the internal structure leads to premature grid failure. Another tetrode family, the 4CX250 series will cover an even greater power range in a compact package, either in the force blown form or in the form that is gaining popularity, the conduction cooled version. Newer releases, like the 8873 series appear to be variants. (No pun intended!) In pure triodes, the 3-500Z series would appear to be the obvious choice. According to the manufacturer, these tubes come under various names, and some of the alternatives are of some interest. A particular one is the QB3/300, a European version of the American 6155, itself a version of the 4-125A.

This tube, which is used in the linear to be described later, has several features which recommend it particularly to our broad specification.

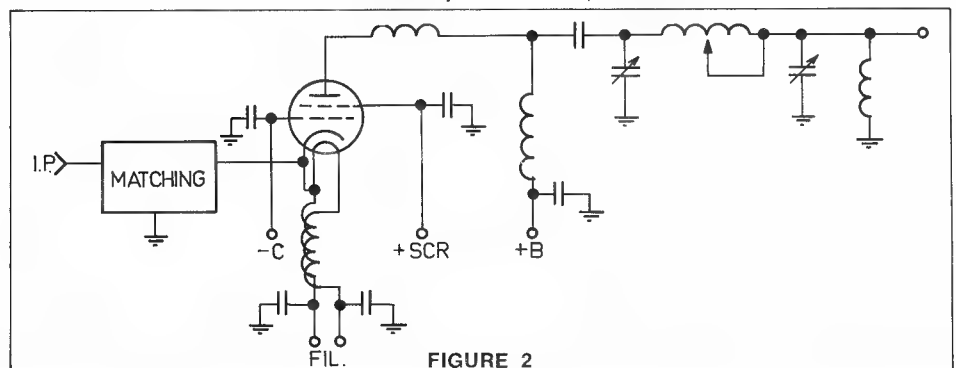


FIGURE 2

The tube is useable to 200 MHz, the anode self capacity is low enough not to cause serious problems, it is compact, and under grounded grid, grounded screen, and zero bias, two tubes draw about 10 mA each to operate well in Class B, and deliver the required power over the 80-10 metre bands.

A feature of this tube is that the filament dissipation is a mere 32 watts per tube, and it is not necessary to force cool the filament pin seals as it is in all the larger tubes. However you would not normally go out to buy a pair of these tubes, as a single 4-250A or 4-400A, whilst it needs force cooling, is about the same price as a single QB3/300, or 4-125A for that matter. Both the QB3/300 and the 4-125A have appeared in small quantities from surplus sources in this country. As another hint, considerable quantities of these tubes are used in both broadcasting and television service.

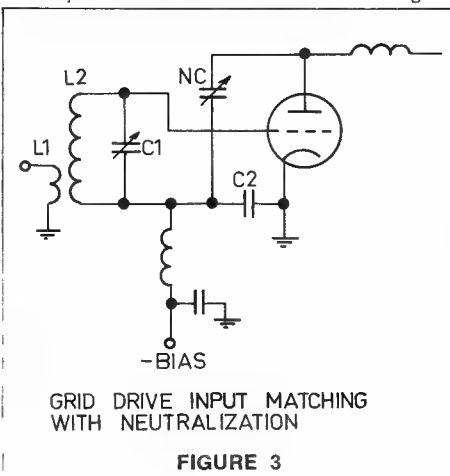
Manufacturers and technical writers often give the intermodulation performance of individual tubes as a measure of their linearity. These figures are of great importance in the design of TV power amplifiers and their use in audio SSB service will indicate the stage linearity at the stated drive and power levels. In general, tubes under hard drive conditions will have poorer linearity than the same tubes treated a little more gently. A 6146 driven hard at a high plate voltage will give an intermod figure of -19 dB whilst at a moderate plate voltage, and of course lower power output, will give a figure of -23 dB or so.

Tubes designed for linear service tend to demonstrate low figures also. Consider the 6146B (YL1370) under the hard driven high output case above: whereas the 'class C' 6146 gave -19 dB, the 'linear' 6146B will give the considerably improved figure of about -26 dB. Tubes primarily developed for linear service, rather than a modification as in the case of the 6146B, may demonstrate intermod figures better than -30 dB. In general, the more negative this number, the better.

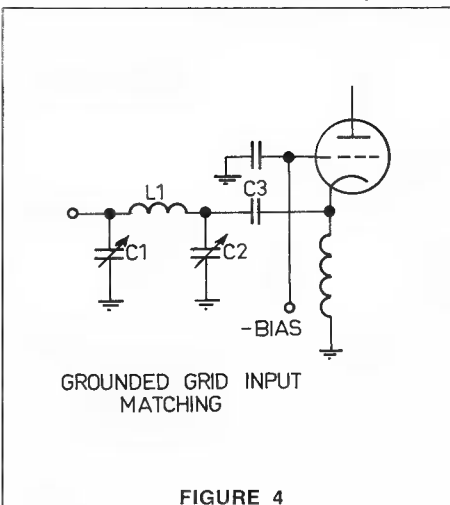
At this stage we are beginning to get an idea of what the linear is going to need in the way of power, roughly what size it is going to be, and approximately, how the unit is going to perform. But as yet, we do not know what the circuit is going to be, although we may well have an accurate guess, what the required drive power will be, or what the component sizes will be. Unfortunately, it will not be possible in these pages to cover every possibility of design. Most designs will be controlled by what components are available from the junk box, or what can be obtained from a friend who knows a friend. So what will follow now will be rather a generalisation quoting particular examples where appropriate.

There are two basic circuits that we might use, the driven grid, Fig. 1, or the more popular driven cathode, or grounded grid Fig. 2. Each of these circuits has its advantages. In the case of Fig. 1 the required drive power is very low, but the

matching circuit must be switched for each band and neutralisation must be provided in the majority of cases. Fig. 2 requires a higher driving power, most of which appears in the output, but does not require neutralisation when well designed, and the matching unit is less critical than the matching unit of Fig. 1. In USA, where the input power to the anode is controlled by regulation, it is an advantage to have the drive power transfer of the circuit of Fig. 2.



First things first, we shall consider the input matching circuit. One of our technical specifications was that the input impedance should be around 2:1 against 50 ohms, that is 25 to 100 ohms if purely resistive. Unfortunately, the tube inputs are rarely within this range and an impedance matching network is required. Fig. 3 shows a typical circuit for a driven grid amplifier with neutralisation. The circuit L2 and C1 are resonant at the operating frequency, the impedance ratio being controlled by the square of the turns ratio L2 to L1. Neutralisation is accomplished in the usual manner by means of the feedback divider NC and C2. The circuit is complicated and from the home brew point of view represents work that we would prefer to do without. On the other hand, if you wish to drive the legal limit from an Argonaut or similar exciter, you will need this configuration to obtain the sensitivity required. Individual networks would be required for each band, but with any luck, it



may not be necessary to retune the drive circuit within a band. A linear built for monoband use would not need switching, and this circuit is not unattractive. The impedance ratio required for this circuit is quite high as most grid circuits operating in class AB or B have impedances in the thousands of ohms area.

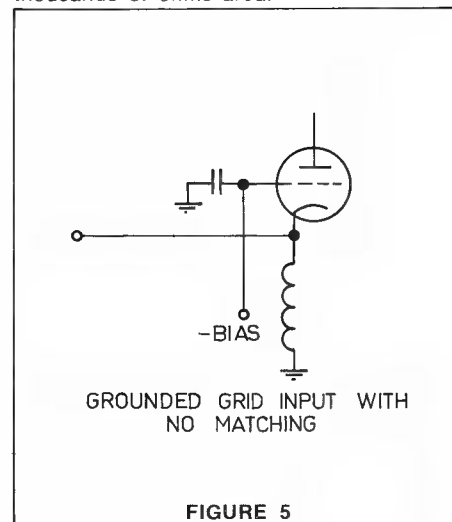
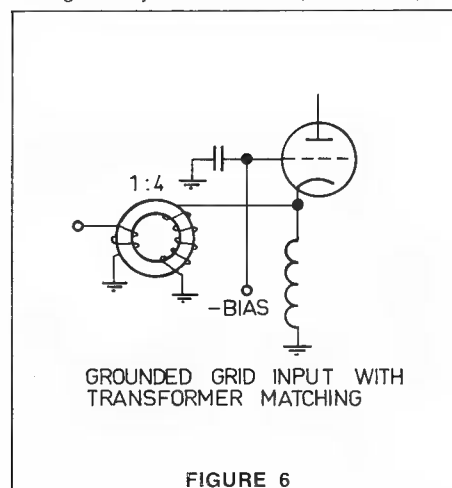


Fig. 2 shows a typical Pi coupler input circuit for a grounded grid amplifier. The impedance looking into the cathode of such a circuit will be up to 500 ohms for some smaller tubes and down to about 100 ohms for the largest tubes that we are likely to use. The general design of Pi couplers will be covered in the section concerned with the output of the amplifier. Again, switching will be required for each band. In this circuit C3 is a DC blocking condenser and as there may be a blocking condenser in the exciter, C3 may in some conditions be omitted. If this is done and directly heated filaments are used, make sure that the input is hard connected to the earthy side of the filament circuit. For centre earthed filament circuits, we have little option but to incorporate C3. The reason for this precaution is to save the filament choke in the event of an accidental short on the input circuit. If we use tubes like the 4-1000A, the input impedance will be about 100 ohms, no additional matching will be required, and the circuit of Fig. 5 may be used with, of course, the



precaution regarding a DC blocking condenser. It may be that we would like to avoid this matching unit altogether. Certainly there are some excitors that will match into more than 100 ohms, and some home brewers will waive the 100 ohm input requirement.

There are two special circuits which are worth a mention. Fig. 6 shows the use of a 1:4 transformer wound on a toroid for use in a grounded grid amplifier. About a 2.5 cm toroid with 8 turns primary and 16 turns secondary 18-20 SWG interwound should be suitable. This would cover 80 through to 10 and would not require switching, and would put the input impedance within the range specified in our general requirements.

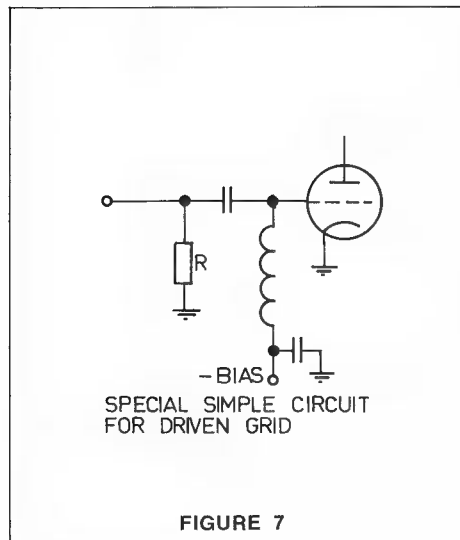


FIGURE 7

The other special circuit is that shown in Fig 7, where a resistor R is placed in the grid circuit. Remembering that the grid impedance is high, R may be made about 70 to 100 ohms. It needs to be a low inductance resistor at the highest frequency used, and large enough to dissipate the power generated in the exciter.

The principle here is that the exciter develops a RF voltage across the resistor sufficient to drive the tube. The power required from the exciter will be similar to that required were the same tube driven in grounded grid, but this circuit has the advantage that the input impedance is well controlled and tuning can be accomplished easily. For instance, the exciter can be tuned into the linear without the power being applied to the linear. The load resistance R will need to be a non-inductive 20 to 50 watt resistor. Such a unit may be the usual combination of a dozen or so 2 watt carbon resistors soldered between two brass discs, the whole lot sitting in a bath of oil.

Reverting for a moment to the circuit of Fig 3, there will be cases where the neutralising capacitor NC may be omitted. This will be the case if a tube designed for VHF or UHF operation is used at lower frequencies. Tubes like the 4CX250 have very good input to output isolation and neutralisation is generally not necessary.

(To be continued)

THE 11 AND 10 METRE BANDS THROUGH THE BOTTOM OF THE SOLAR CYCLE

Sam Voron VK2BVS
2 Griffith Ave., East Roseville, 2069

With the ITU 1979 examination of all amateur bands and their utilization here are details of some efforts being made to more fully utilize our 11 and 10 metre band allocations.

THE 28.5 MHz LOCAL 10 METRE NET

Several stations around Australia and New Zealand are now continually monitoring this frequency. The idea being when you are in your shack to keep your receiver on this frequency as a local communications net and (if busy) as a calling frequency. (28.550 and 28.600 MHz being secondary channels). The main reason for not choosing 28.6 MHz as primary is that during International DX openings this channel would be unusable for local workings; however, 28.5 MHz being on the edge of the 10 metre DX tunable range offers a relatively clear frequency while still allowing DX stations to tune into and join the net.

By encouraging the formation of local nets in Australia, New Zealand and New Guinea we can hope to maintain a high level of activity on 10 metres throughout the year.

In previous years the difficulty on 10 metres has been that operators normally tuned across the band, heard nothing and so went back to the lower frequencies. However with the formation of a local net in Sydney on 28.5 MHz, many were alerted to a recent opening into Europe on the 2/11/75 from 7 to 10 p.m. when DK5MY in Munich was worked with only 80 watts and a quarter wave 27 MHz ground plane, on the 24/11/75 from 3.30 a.m. till 5 a.m. into Northern America, and on 28/11/75 a Sporadic E opening permitted contacts with Hawaiian stations using 20 watts output with KH6IJZ being worked for 25 minutes from 5 p.m.

These show that the bottom of the sunspot cycle can be an exciting period on 10m. Openings to the Americas and Europe will occur especially at the commencement and break-up of geomagnetic disturbances (as warned on WIA/IPS broadcasts). Interstate contacts will be regular and strong for nearly 3 months every summer and mid-winter as is the case with 6 metre Sporadic E propagation. Sporadic E, backscatter, and tropospheric modes will also be little affected by the sunspot cycle.

These types of propagation are being observed simply because the existence of local nets serves to foster continuous use of the band. So why not activate a local 10 metre net in your area? By encouraging mobile, portable and base station monitoring of 28.5 MHz, together with a weekly

submission of 10 metre local and DX news to the WIA Divisions for broadcast, you will soon find you have developed an active net in your area. Continuous local activity of our upper HF spectrum seems the first step in increasing our utilisation of our single biggest High Frequency assignment.

This has worked very well on the 160, 11 and 10 metre Sydney nets to such an extent that the two former nets now have a WIA broadcast twice each Sunday and consideration is being given to a 10 metre coverage.

THE 27.125 MHz ALL MODE LOCAL 11 METRE CALLING CHANNEL

More than 1000 persons applied to sit for the first Amateur Novice exam in e 1976. This means that the high level local activity on the 11 metre band will require stations to shift to another channel as soon as communications has been established. Also, because the Novice will be crystal locked, amateurs using tunable equipment should be aware of certain procedures which will help him contact our new Novices.

(1) As there are 22 standardised channels in this band, the typical procedure is to establish contact on the calling frequency (channel 14) and then on phone or CW, arrange to QSY to a clear frequency.

(2) Amateurs using tunable equipment and listening for a reply to their CQ call should remember that the Novice is crystal locked. He or she cannot come onto your frequency and so you should tune ± 3 kHz either side of your frequency if you are calling on a net or alternatively tune the whole band for a reply to your call. Remember also to initiate your call on one of the standardised 22 channels as these are the crystals Novices will find most easy to obtain. The 22 channels are:

1. 26.965 MHz	12. 27.105 MHz
2. 26.975	13. 27.115
3. 26.985	14. 27.125
4. 27.005	15. 27.135
5. 27.015	16. 27.155
6. 27.025	17. 27.165
7. 27.035	18. 27.175
8. 27.055	19. 27.185
9. 27.065	20. 27.205
10. 27.075	21. 27.215
11. 27.085	22. 27.225

In Sydney, Ch. 11 is a secondary channel and Ch. 5 is a tertiary one for persons using 3 channel units. Ch. 2 and 21 are not used in many centres such as Sydney due to interference from hospital paging units.

(3) Many amateurs are using inexpensive 1 watt AM walkie talkie sets, and these are capable of coverage of over 1000 miles given the right conditions and antenna arrangements.

A LINEAR POWER AMPLIFIER FOR AUSTRALIAN CONDITIONS

PART TWO

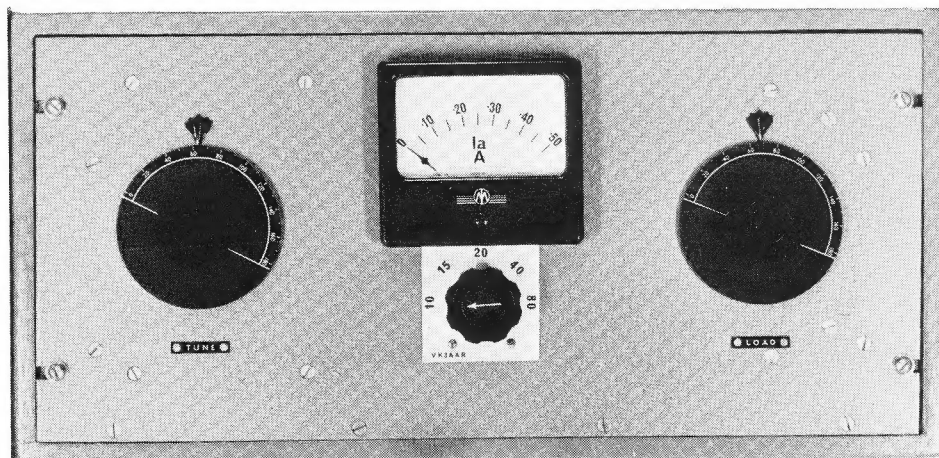
R. A. J. Reynolds, VK3AAR

The subject of screen and bias voltages will be controlled very closely by the tubes chosen, and the manufacturers recommendations should be followed for the plate voltage chosen. There are a few observations which should be made. It is important that the bias and screen voltages are well controlled. Preferably they should be regulated and well bled. There are some tubes, particularly in the 4CX250 class, which can draw negative screen current, and if the supply is inadequately bled, the voltage will rise dramatically and the tube, to say nothing of the filter components in the supply, will fail prematurely.

The rest of the design is basically the same for all amplifiers of this class. The output stage will consist of a Pi coupler whose purpose is to match the impedance of the plate circuit to that of the antenna feedline. The plate circuit impedance will be as low as 500 ohms in the case of a handful of sweep tubes, and as high as 8000 ohms in the case of a couple of 4-125As under grounded screen zero bias with 4 k V on the anode. The required output impedance from the coupler will depend on the antenna to be used, and we have stated that it must be at least a 2:1 SWR against 50 ohms. Flexibility to match loads outside this range is, of course, to be encouraged. At the same time as providing an impedance match, the coupler will provide the output filtering necessary to remove or at least attenuate the harmonics present in all amplifiers other than purely Class A.

The Pi coupler consists of three components which, in Fig 1 are C3 L and C4. The rest of the components around this circuit will be discussed later.

An excellent treatment of the general design of Pi couplers suitable for linear amplifiers is given in the 'Radio Data Reference Book' by G. R. Jessop, which is a RSGB publication. The treatment in this book covers the design for use in various classes and services of amplifier. Both the input and the output Pi couplers are considered by means of one or two basic equations and a series of ABACs and graphs. About 20 pages of this book are dedicated to this subject, and even if



Front view of the VK3AAR 400W PEP linear

a home brewer does not build his own coupler, a read over these pages will give an insight into just what happens in that rather magical unit.

Very briefly, the design involves calculating the RF waveform impedance at the anode, stating the output impedance at the transmission line, and then for each band, applying the ABACs and graphs to determine the values of C3 L and C4 required for Fig 1. The ABACs and graphs are for a loaded Q of 12 which is satisfactory. Greater or lesser Q's are used but a Q of 12 is stated to be a good compromise for filtering and component size.

Since we have opted for a power output of about 400 Watts PEP and the general trend seems to be towards a power supply of about 2500 to 3000 volts for the anode, out input impedances will all be about 4000 to 5000 ohms and we have already stated that our output impedance will have to cover the range 25 to 100 ohms. This virtually fixes the design of the output coupler. The only situations where major design variations will occur will be the case where a handful of sweep tubes is used, and the case where tubes are run at very high voltages. Both of these cases will require individual treatment. Several designs have appeared for the sweep tubes, and only the more adventuresome of us will try the 4000 Volt class. Fortunately, a single design of Pi coupler will therefore suit nearly all linears built for Australian conditions.

Considering that such a unit, or at least the coil and switch assembly, is available commercially at a very moderate cost, there does not seem to be much point in home brewing this assembly. The cost is less than a single output tube, and if one tube is saved from destruction in the 'turn on' testing by having the right inductance in circuit, then the investment will be worthwhile. A suitable unit, which covers the 80 to 10 Metre Bands, is available from William Willis & Co. Pty. Ltd., 77 Canterbury Road, Canterbury. One word of comment. The switch unit on this assembly will handle 400 Watts without distress, but operation at 600 Watts CW with an HT of 3700 Volts did cause switch failure, as did

trying to use the second bank of contacts to switch a little more primary capacity for the lower bands. These failures occurred during limit testing of a prototype. (No, into a dummy load!)

However, in normal service, no problems should be experienced. The efficiency of the Willis coupler was such that no fall off of performance was observed at 10 Metres when used with high frequency tubes. A capacitance range of 30 pF to about 200 pF was required for the input capacity and up to 1000 pF is required at the output. Remembering that there will be about 10 pF anode capacity in the output tubes, this means that C3 will need to cover from 20 to 190 pF or so. There may be some difficulty in achieving this from available variable capacitors, and special precautions may need to be taken. This will be discussed in the construction section of this article. Since there may be a desire to feed a low impedance aerial directly on 80 metres, a 1000 pF variable in the output may need to be augmented with another 750 pF fixed capacitor. A switch contact on the Willis coupler is provided for this purpose.

As far as the design of a typical linear is concerned, all that remains to be considered is a few minor components. With reference to Fig 1, consider each in turn.

RFC1

This is the HT choke. No matter what the rest of the design is, this choke will be almost invariant. It needs the following properties. It must have a reactive impedance which is high compared with the plate impedance on all bands, it must be able to carry the DC plate current without resistive loss, and it must be able to withstand several thousand volts of RF longitudinally.

Many designs have appeared for this choke in varying complexities, since there is one problem. That is that the self resonance of a coil wound for a high impedance at 3.5 MHz is likely to lie in the area 10 to 30 MHz. Now it is important that the self resonance frequency is not near any of the Amateur Bands, and systems of staggered winding pitches, varying diameters, and combinations have all been

tried with success. However, even the simplest design does work. A piece of 3/4 inch diameter Teflon close wound with 24 SWG high quality enamel wire for a length of 3 1/4 inches, self resonates at 17 MHz as determined with a GDO. There is nothing magic about those dimensions, they were just a guess. At all events, this choke has been satisfactory on all bands without heating. (Turn power off and make sure that the HT is discharged before feeling how hot the choke is!)

C1

This is the very important DC blocking capacitor. To provide maximum coupling it must have a low series impedance at all operating frequencies. The performance at 3.5 MHz requires that the capacity must be greater than about 1000 pF and the heating performance at 30 MHz requires that the capacitor type must be a low loss coaxial ceramic type. The fact that the HT is about 3000 Volts or so demands that the voltage rating should be well in excess of this figure. Since the matter of safety also comes into this, it is suggested that a working voltage rating of 7.5 kV DC or better be chosen. Capacitors similar to those manufactured by Centralab (Series 850S) are suitable.

C2

A 1000 pF 5 kV mica will serve as an adequate bypass capacitor.

RFC2

This RFC serves two purposes. Firstly it provides a DC path to ground should the DC blocking capacitor fail, and secondly it provides a static drain to clear static build-up from the antenna which can fail the blocking capacitor.

A third use for this component was discovered at VK3AAR. The linear was being used into a dipole without a DC return path, with a Bird thru-line wattmeter in circuit, and the application of the HT to the linear induced a sufficiently large pulse through the blocking capacitor (1800 pF) to destroy the diode in the wattmeter element. Fitting the choke removed the

problem. The size of this choke is not important and about 1 mH is adequate. However, the wire size should be large enough to blow the main power fuse should the blocking capacitor fail. For example a 2 cm ferrite ring wound with a single layer of 24 SWG enamel wire works adequately.

APC

The Anti Parasitic Choke will be a composition type carbon resistor about 50 to 100 ohms, "Shorted" by about 2 or 3 turns of 16 SWG tinned copper wire. One will be required in each anode lead. This choke suppresses VHF spurious emissions.

Grid and screen bypass capacitors will be 1000 pF disc ceramics or similar.

The only other component to be found in the linear where design is required is the heater choke required for the grounded grid amplifier. The size of this choke will be controlled by the filament current. An air choke to carry the 14 or so amps required by most tubes, having at the same time a high RF reactance compared with 300 ohms, would be quite a monster. Fortunately, we can resort to the use of ferrite once again. There seems little point in doing an absolute design, and the experience of others yields a unit that is easy and cheap to construct. An ordinary broadcast band ferrite rod about 1/2 inch diameter, bifilar wound with 20 turns of 16 SWG enamel wire, gets a little warm at 14 amps, but operates quite well.

Apart from a few practical aspects that become evident when the linear is being built, and which vary from unit to unit, the above covers the general design of the amplifier part of the linear. Jumping the gun a little, and considering the final construction, it is possible to build a satisfactory linear with no input matching circuit, no screen supply, and no bias supply. The final circuit will be as shown in Fig 8. This would appear to be the simplest circuit that I could build within the components that I had available. There is nothing unusual or novel about this circuit, but under test it does deliver 400

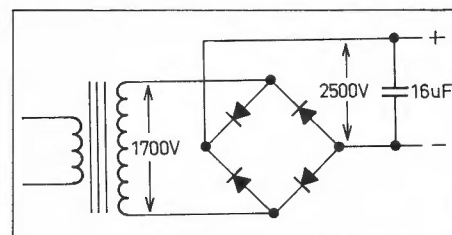


FIGURE 9

watts PEP on all bands using a 2-tone test into a 50 ohm dummy load, with a minimum of fuss.

Whilst not part of the linear amplifier itself, the design of a power supply is worth more than a passing mention. We have already established that we need between 1000 and 4000 Volts, at currents that we can deduce to be between 1 Amp peak at 1000 Volts and 250 mA peak at 4000 Volts. Under misalignment the peak currents may be twice these figures. The average currents will be about half the above currents.

However, over a period of several hours, the mean energy required from the power supply will be quite low. This raises several problems with regard to just how large the power supply components need to be. Again there is no single solution to the problem. The simple alternative of RF speech processing or not changes the power supply size by some 20 to 30% when processing is used.

For the home brewer the power supply is likely to be the most expensive item, particularly if he does not already have a power transformer and filter components. So it is well worthwhile examining the design of the power supply in some detail, if only to avoid expensive mistakes. As in the case of the linear amplifier itself, let us establish the requirements of the supply.

Input power: 240 V AC single phase.

Output Voltage: Let us consider an average of 2500 Volts.

Output Current: Syllabic maximum: 500 mA.

Average (5 minutes): 350 mA (speech processed), 250 mA (unprocessed).

Average (1 hour): 150 mA (speech processed), 110 mA (unprocessed).

Ripple at 500 mA: Better than 3%.

Regulation: From zero current to syllabic maximum: 10%.

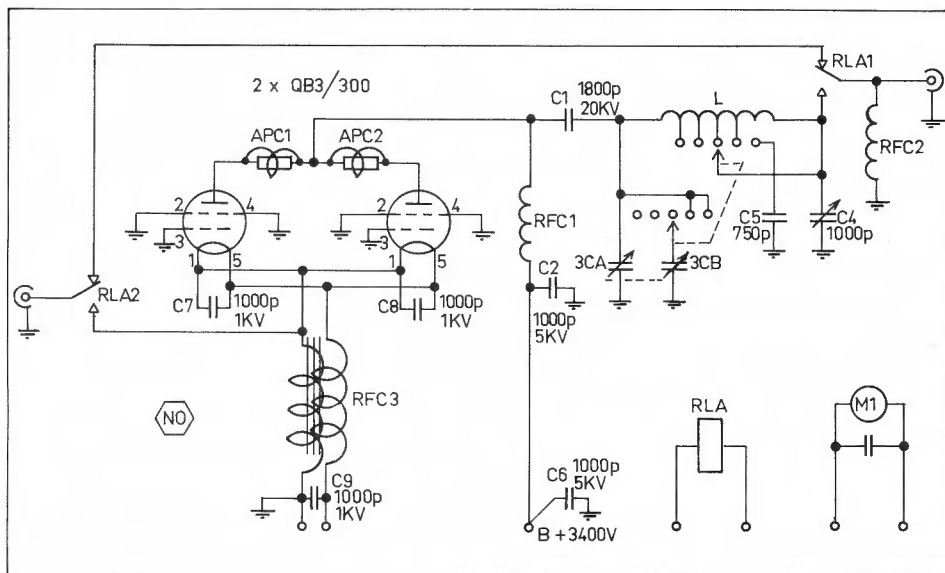
Subsidiary supplies: Filaments: 5 Volts at 15 Amps; Relay supply: 24 Volts DC at 500 mA.

Metering: Plate current, 0 to 500 mA.

Plate voltage, 0 to 3000 Volts.

The justification for setting the above targets rests with experience and the accepted practices. Certainly the average current ranges will vary somewhat from operator to operator, so it will not be unreasonable if we consider the worst conditions in the following treatment. The individual may choose for himself if he wishes to cut down on the design.

Both at the commercial and home brew levels, the design of power supplies varies



greatly, and particularly if you have certain major components, you are quite justified in copying an established circuit. Let us consider the pros and cons of some of the more usual power supply configurations.

FULL WAVE WITH A PAIR OF 866s AND CHOKE INPUT

This circuit is the traditional one. Its advantages are that the regulation is very good, the current in the rectifier tubes is kept as low as possible and high value capacitors are not required. Against it are the higher transformer voltage, the high bleed current and the large swinging choke that are required. The use of 866s would seem to be dubious in these days of semi-conductors.

VOLTAGE DOUBLER

This class of circuit is quite popular in the 1000 Volt output class. The power transformer is quite easy to make, high current rectifiers are cheap and available, and high value 600 Volt electrolytic capacitors are not over expensive. However, at higher voltages, electrolytic capacitors have to be cascaded to obtain the high working voltages needed. A general problem with doubler circuits is that the ripple and regulation is poorer with the same total capacity compared with a full wave circuit.

HALF WAVE RECTIFIER

This circuit has many of the problems of the voltage doubler circuit, and in these days of inexpensive solid state rectifiers, there is much to be gained by using a full wave bridge, using the same power transformer.

FULL WAVE BRIDGE

At voltages near the 2.5 kV that we are considering the full wave bridge has many advantages. It provides the best ripple performance obtainable with a single phase circuit and consequently minimizes the size of the filter components. In fact, for a linear amplifier, adequate filtering may be obtained with a single storage capacitor. The disadvantage of this circuit is that a power transformer of high voltage output is required, and the output winding must be floating; that is no part of the winding may be connected to earth. This latter fact does present problems to the transformer designer.

With all this in mind, the logical choice for our linear power supply would be the full wave bridge, or if a suitable transformer is available, a conventional full wave two diode circuit. The best generally available method for power supply design is that detailed in the Radiotron Designers Handbook edited by Langford-Smith. For each circuit type that we have mentioned, plus a few others, curves are published from which the regulation, ripple and component ratings can be obtained for a given circuit. Conversely, given some of the parameters, the remainder can be deduced.

Using this design method for our general example we discover that the ripple requirement predominates and that a 16 μ F single storage capacitor will suffice. Of course, it would be possible to use a

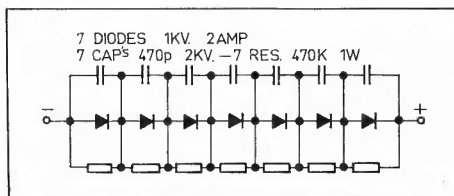


FIGURE 10

smaller input capacitor of 6.5 μ F followed by a 10 henry filter choke followed by another filter condenser of 1 μ F. My opinion is that these extra components are not necessary, and since the single condenser circuit improves the regulation from 10 to 7%, the larger value is to be preferred. So the rectifier circuit becomes that shown in Fig 9.

Since we are using a condenser input filter, the required transformer secondary voltage is the output required DC divided by the square root of 2, which works out to be 1770 Volts. The storage condenser will need to be rated for a working voltage of something greater than 2500 V DC. The fortunate amongst us will reach into the junk box and find a 16 μ F 8500 V DC paper capacitor weighing about 10 kilos, as I did, the rest might find kind friends or be forced to "manufacture" such a unit from several electrolytics fitted with balancing resistors.

Continuing with the design method we discover several more important design parameters. Each of the four diode legs will have an average current of about 250 mA, a repetitive peak of about 5.5 Amps and probably a turn on surge current of about 30 Amps. It is quite easy to see why simple circuits like this were not used in the days of valve rectifiers. Even now, some care will have to be taken in the choice of diodes. Using a factor of safety of 2.6 for PIV, a figure which is satisfactory for unprotected circuits, each leg will have to be rated at more than 6500 peak inverse volts. Following the usual practice, each leg could consist of 7 diodes

each rated at 1 or preferably 2 Amps average forward current and 1000 volts reverse, connected in series, each diode having a 470 pF 2 kV disc ceramic condenser and a 470 K 1 W resistor in parallel across it. So each leg will look like Fig 10. There is little point in saving pennies in the diode department, and the above calculations are based on the syllabic current.

The power transformer does not have to work this hard. Diodes heat up quickly, but transformers take some time due to their mass. Hence, the transformer need only be rated at something like the 1 hour average.

Considering the speech processed case, the average DC output is 150 mA, which means that the transformer will have to be rated at something like 230 mA RMS, or 400 VA continuous. For this sort of service the expression IVS or intermittent voice service is used. The IVS rating for the transformer we have just described is about 1350 VA IVS. It sounds better anyway. All the same it is a fairly lusty transformer, and one which you would prefer to buy at disposal prices.

Two other supplies are required, the filament and relay voltages. The filament supply may be obtained from a separate filament transformer, or if there is room on the main transformer, sufficient turns of a suitable gauge wire may be added to obtain the correct filament voltage. Much the same can be said of the relay supply. In the case of my own unit the main transformer provides the HT and filament windings, whilst a small 18 Volts aside transformer raises 24 volts DC by means of a couple of diodes and a 1000 μ F 30 V electrolytic. These fine details will depend very much on the size of the junk box.

A suitable power supply circuit for the linear amplifier of Fig 8 is shown in Fig 11. A conventional voltage divider and shunt is used to adjust a meter to read supply voltage mounted on the supply chassis, while a 1 ohm shunt and adjust-

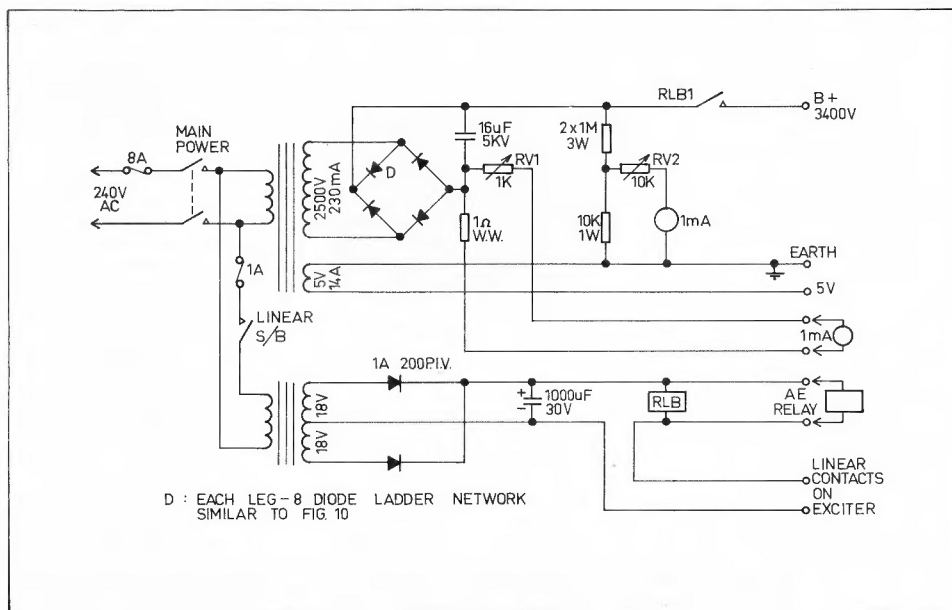


FIGURE 11

able multiplier operates a remote meter mounted on the linear chassis indicating anode current. Note that this arrangement does not permit the high voltage to be applied directly to the meter movements. During receive, the HT must be removed from the anodes to avoid noise and possible receiver destruction should the final take off. A long throw circuit breaker RLB connected in parallel with the aerial changeover relay RLA removes all but the filament power from the linear chassis.

There are alternative methods for removing the HT from the tubes. Opening the cathodes with a smaller circuit breaker will bias the tubes hard off, but will leave the anodes high with respect to ground. Removing the 240 Volt power from the transformer, or opening the high voltage secondary will all kill the HT, but will introduce the problem of high surge currents each time the press to talk or vox operates.

This concludes the electrical design of the linear and power supply. A design has been deduced that is as simple as possible, using a minimum of components at what should be a low total cost, certainly less than a completed commercial amplifier. The only design parameter that we have relaxed is the input impedance, which we could modify should we wish to do so. Probably the only facet of the overall design that we have not covered is the mechanical layout. A few general comments can be made, but the choice of tubes possible and the range of parts that may be available to the constructor, makes

a general mechanical layout impossible. My feelings on general details are as follows:

I consider that the power supply should be enclosed in such a way that the high voltage components may only be touched with difficulty, and this must include abuse by any person. Ventilation holes should be small and even covered with a fine mesh. The use of a suitably large transformer and solid state rectifiers may permit a completely closed box. An adequate power earth should be provided through the input power cable. This prompts an interesting detail. A problem that is observed by many linear operators is the syllabic modulation of the power mains. It is not unusual for an exciter and linear combination to pull current from the mains varying from half an Amp to about 8 Amps. This causes lights to flicker, VFOs to drift and all sorts of associated problems at a syllabic rate. So it might be necessary to power the linear from a different power circuit. Operators with shacks remote from the domestic power board, may have to run a second power feed to the shack. Even with normal supply regulation, a variation of about 5 to 10 volts is quite possible on the 240 volt mains.

The linear amplifier itself should be well screened, and at the same time well ventilated. The use of perforated or expanded metal achieves both these aims. As well as a coaxial earth to the exciter, a separate earth to the exciter using a length of recovered coax outer will help to reduce RF feedback. In operation, the increased

quantity of RF around the shack due to high transmitter output may increase the possibility of RF feedback in general. The usual treatment of improved earthing, removal of RF current on coax outers, and general shielding will correct the problem. So, a little elementary design, a little construction, and you too can say . . . "An FT101E into a homebrew linear running the legal limit". (Next month the author describes his success in building a 400 W PEP linear covering 80 through 10). ■

.....

daicom

AMATEUR COMMUNICATIONS SYSTEMS

**32 KALGOORLIE CRES., FISHER,
ACT 2611**

PHONE 88 4899

UNIDEN 2020*	\$600
ICOM *IC22A 2m FM mobile with 6 channels	\$2
ICOM IC202 2m ssb 3w	\$2.
ICOM IC502 6m ssb 3w	\$220
ICOM IC21A 2m FM base	\$300
Crystals for IC21/22A	\$9 pair
Novice AOC Study Pack	\$10
Morse cassettes	\$3
Coaxial cables, connectors, adaptors etc. Mike plugs, antennas, spares.	
SUP minimum-of-fuss kits for converters, amplifiers available.	

Used equipment not normally stocked but enquire anyway. Our specialty is selection advice!

Prices and specs are variable.

*authorised distributor of
ICOM and UNIDEN for VICOM.

.....

A LINEAR POWER AMPLIFIER FOR AUSTRALIAN CONDITIONS

PART THREE

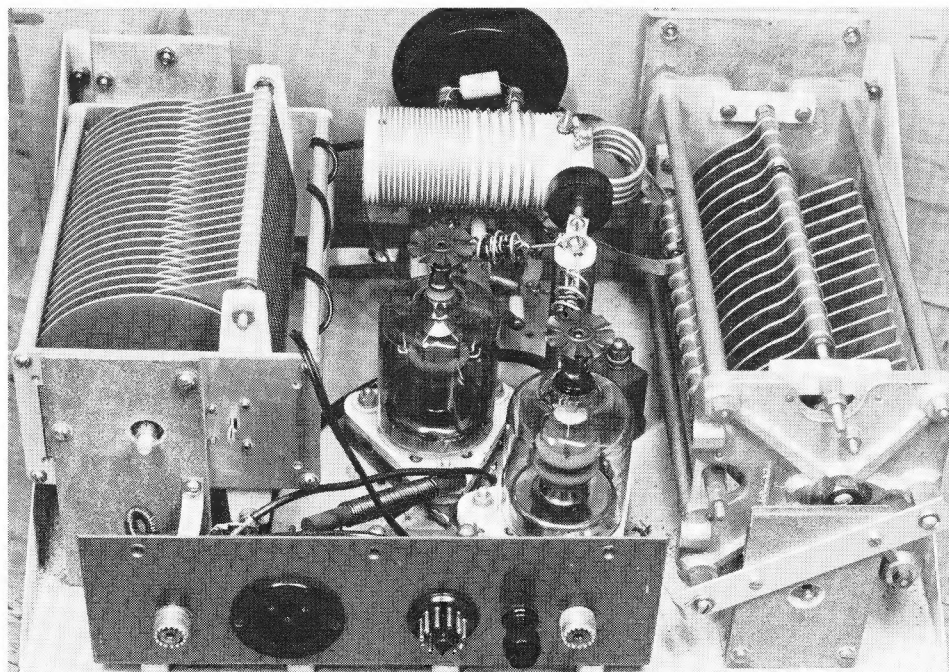
R. A. J. Reynolds, VK3AAR

CONSTRUCTION DETAILS

As in most home brew projects, the final design of the 80 through 10 linear at VK3AAR was somewhat governed by the major items that were in the junk box, at the local disposals sources, and available from friends. The prospect of reproducing the amplifier about to be described in exact detail would be formidable. Many of the components are very much 'one off' in the writers experience, even though they must have been made in considerable numbers some years ago.

The VK3AAR junk box is quite extensive, but even so, did not extend to adequate tuning and loading capacitors, a Pi-coupler, a chassis and cabinet, or a convenient power transformer. There were of course a handful of minor components that had to be found. On reflection, these items represent the bulk of the amplifier, so it cannot be assumed that the VK3AAR amplifier will be all that different from any other attempt. One feature is worthy of note. The overall cost of such a unit is considerably less than that of a commercially available item. In my case, the total cost over and above the bits from the junk box was a little over \$50. There is little doubt that I could have built an amplifier for even less cost by less suitable items from the junk box, such as TV power transformers strung up in series, an old chassis, chopped up broadcast condensers, and bits of copper wire wound into a Pi-coupler, but I considered that in order to present a prettier unit, a little money had to be spent.

The circuit diagrams are those shown in Figs 8 and 11. These circuits are of course flavoured by the components available. For example C3A and C3B could be replaced by a single variable capacitor 10 to 200 pF at about 5 kV spacing. In my case the



available unit was 30 to 200 pF, and the stator had to be sectioned and switched to achieve a low capacity for the 10 to 20 m bands.

The theoretical derivation of the circuit was covered earlier in this series, and the prospective constructor would be well advised to become familiar with the reasons for the choice of each component. For example, whilst the range of value for C3 needs to be fairly close to the circuit value, that for C1 could be anywhere between 1000 and 3000 pF. Hence, the circuit value for C1 which is shown as 1800 pF, could be relaxed to 1000 pF in order to use a junk box component, whereas a 20 to 180 pF variable could hardly be used for C3 without additional padding for 80 metres and may be sectioning for 10 metres.

The following description is peculiar to the VK3AAR linear and the components that were available for its construction. Some concluding notes on tuning, testing and operating will be common to all amplifiers, although here again there is more than one way of doing a job, and the availability of support equipment will dictate the methods used by individuals.

The chassis, front panel, cabinet, complete with the two variable capacitors were purchased from surplus sources. This unit was originally an aerial tuning unit for an unknown service. It was apparently equipped with plug-in coil units designed to cover a range of frequencies. Evidently 50 or more of these ATUs have appeared in Melbourne in recent times, and possession of such a unit would make the construction of a linear somewhat easier.

The two variable capacitors in the ATU are a Jennings 1000 pF air variable rated at 3500 Volt spacing and a 30 to 200 pF air variable of unknown manufacturer, which would appear to be about 6000 to 8000 Volt rating. These capacitors serve

as the loading and tuning capacitors. The identification on the front panel is even correct.

Because of the design of the plate tuning capacitor, the minimum capacity was too large for operation on 10 and 15 metres, and the setting somewhat too close to the minimum capacity for convenient use on 20 metres. This situation was remedied by sectioning 4 of the stator plates so that only these four were in circuit for the higher frequency bands. This involved dismantling the unit, cutting the stator support rods at the appropriate point, threading each of the cut ends and fitting these ends with a fairly thin nut, so as not to cause arcing between the stator sections on the higher bands. Care must be taken not to strain the ceramic insulators that support the stator assembly, or an annoying fracture may occur. No additional support was required for this unit as there are three support rods for each section.

Provision was made to switch the extra section into circuit for operation on 40 and 80. It would of course be most convenient if this could be ganged with the band change switch, but this does create some problems. There is a spare set of contacts on the Willis Pi-coupler that I used, however the switch failed almost instantly when used for this purpose. The RF voltage present on the switch that couples this extra C is in the order of kV's and somewhat special precautions must be taken. If there is plenty of room a large ceramic switch or a mechanical coupling to a special second switch could be used. Alternatively a separate control on the front panel might be used for 10-15-20 in one position and 40-80 in the other.

Several attempts were made to repair, modify and eventually replace the switch supplied with the Willis Coupler. The final result was a somewhat elaborate ceramic

The rebuilt transformer had leakages of much better than 5000 Mohms, the limit of my meter, between windings and between secondary and frame. Primary to frame was about 3000 Mohms, which is quite acceptable. So while this might seem like a lot of trouble, it did produce a somewhat difficult to obtain transformer for \$3, 6 reels of tape, and a lot of fun.

The remainder of the components in the power supply are all straight forward with the exception of the relay RLB. This was a long throw aerial changeover relay which came out of another ACU and looked as if it could break 20 kV.

Switching of the primary power and power to the relay control circuit, a voltmeter calibrated 0-5 kV and a suitable cur-

And now to the one strange feature of this unit. The power connection between the power supply and the final is a length of heavy duty 40/0076 3 core power cable.

This piece of cable had a 440 VAC rating, but when I tried it out on a ionisation tester, it went to 20 kV before showing signs of distress, and then it might have been the connector that I used, that broke down a largish 3-pin Belling and Lee power connector with a 20 Amp rating. This cable carries the 2 filament wires, one of which is earthed, and the switched HT. This provides convenience with a certain degree of safety.

Setting up this power supply involves two adjustments, the current and voltage calibrations RV1 and RV2. The former can be set without power applied by means of a 1.5 volt dry cell and a multimeter all in series with a 5 ohm resistor. With the multimeter set to the 250 mA range and the circuit completed through the 1 ohm shunt, RV1 may be set to give the same reading as that shown on the multimeter. RV2 may be set with power on the supply, after measuring the HT with a high voltage probe. Don't take risks with the HT, borrow a proper x100 HV probe and associated meter if necessary.

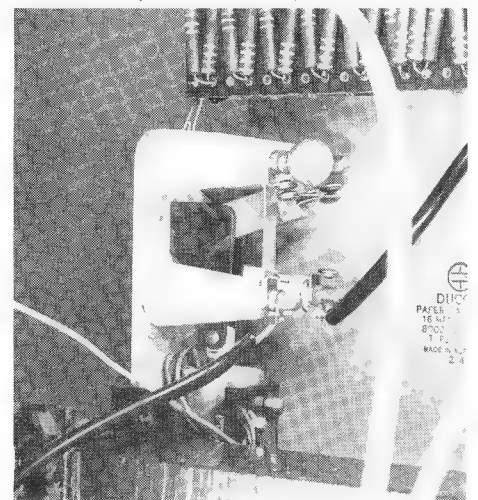
If all goes well the unit is ready to use. Fire it up, load it up and gain that extra 1½ "S-points". I performed some fairly extensive tests on my unit, to compare the overall result with my original targets, and it is not surprising since there was a cer-

At this point in this article, I was going to list the shortcomings of the unit that I built including some solutions that I found. However these solutions were rather messy to say the least, and still did not completely remove the shortcomings. Considering the sequence of events and the subsequent developments, a narrative is of interest.

The problem was that the amplifier appeared to perform well on 20-15-10 metres giving full output, but only moderately on 40 metres (350 W PEP) and poorly on 80 metres (200 W PEP). For operation on 80 metres, the plate tuning condenser needed an additional 50 pF at the low end. The loading capacitor was fully in mesh and with a dummy load of 50 ohms, appeared to be overloaded.

All the same, the amplifier worked well on the bands where my interest lay and I was content to let others concentrate on the 40-80 bands should they require them. Then I decided to pursue the matter and considered the theory of operation of the Pi-coupler. What was the difference between the design of the Willis coupler and the required design for the QB3/300s? It was simply a matter of plate impedance, about 5000 ohms in the case of the Willis coupler that was designed for 813s and about 7000 to 8000 ohms required for the QB3/300s.

The solution was to increase the inductance of the coil on those bands where problems existed. The tap for 40 metre operation was moved two turns towards the aerial end and an additional four turns were added to the coil at the aerial end. Then all was well, the additional 50 pF was removed from the plate circuit and t.l. . whole unit performed well, 400 Watts PEP.



Page 12 Amateur Radio June, 1976

on 2-tone test being achieved on all bands into a 50 ohm load. With comments as required, the performance of the Amplifier was as follows, tested against the original specification.

FREQUENCY COVERAGE

The tuning did cover the Amateur Bands. Although I did not check it on 11 metres, I have no reason to suspect that it will not work there.

EXCITATION POWER

I did not test this fully, however on 10 metres 40 Watts single tone was required to raise 400 Watts at the output.

OUTPUT POWER

Using the approved 2-tone method of determining output power, at least 400 W PEP was achieved on all bands into 50 ohms, however it was noted that considerably higher cyllabic peaks were achieved, as follows: 80 m - 490 W, 40 m - 530 W, 20 m - 640 W, 15 m - 530 W and 10 m - 500 W. I commented earlier that this is due to the power supply regulation.

INPUT IMPEDANCE

This was not tested fully, but from the optimum position of the loading control on the exciter, it was obvious that the input impedance was higher than 50 ohms. On the other hand, I was surprised to observe that the VSWR at the input on 10 metres was better than 1.5:1 against 50 ohms.

OUTPUT IMPEDANCE

On 20-15-10 metres, the amplifier seems to be quite tolerant of poor VSWRs. I have not had the opportunity to test the unit extensively on 40 and 80, but on my observations to date, high impedances should be catered for, but impedances lower than 50 ohms may require more loading capacity than exists at present.

INTERMODULATION PRODUCTS

I have concluded that the measurement of IM within the ham shack with equipment normally available is difficult if not impossible.

However I am indebted to Bob VK3SK for drawing to my attention a method of establishing the "cleanness" of a SSB signal. Many SSB Transceivers and Receivers switch from upper to lower sideband by changing carrier crystals and at the same time shifting the VFO so as to leave the receiver calibration in the same place on the dial. Hence, a receiver set to resolve a SSB signal transmitting USB on 20 metres say, when switched to the LSB position, will be looking at a slot outside the pass band of the originating transmitter. Any signal in the LSB position is unwanted in general, and its magnitude is a measure of the nonlinearity of the system. But remember that this also includes the inspecting receiver and the method breaks down when very strong signals are involved as receiver cross modulation starts to predominate. As an example, a signal indicating S9 + 15 dB on a resolved USB might show S3 in the LSB position. If the output in the LSB position is intelligible then the problem is one of unsurpressed sideband and the test changes its mean-

ing, but if it sounds like broken up duck-talk, then assuming 4 dB per S-point there is 6 times 4 plus 15 equals 39 dB of something. Pretty meaningless by itself, but that figure is certainly related to the intermodulation of the system. And if someone reports your LSB as being only 10 dB down on your USB then something is wrong. Figures of about 30 dB have been considered "clean". The amplifier in question? Reports have been received in the 30 to 40 dB area and appear to be about the same as the "barefoot" condition.

This method of establishing just how clean a signal is, was the subject of some investigation on 20 metres recently when it was verified that whilst power levels from linear amplifiers and exciters involving tuning and matching adjustments do not vary very much with small changes in control settings, the LSB/USB figures as detailed above do change dramatically. For example, a very clean signal from Bob VK3SK gave a figure of about 60 dB, but when he changed the setting of the pre-selector on his Collins S-line transmitter, although he noticed only a little power change, the LSB/USB figure degraded by some 20 to 30 dB! The only indication of change in performance at Bob's end was a distortion of the waveform on the monitor scope. This only emphasises how useful a monitor scope can be. Observation of the output waveform very quickly establishes the state of tune of the whole system. Meter readings become only a check.

POWER SUPPLY

Condition met.

COMPLEXITY

The circuit is simple and straight forward, using no screen or bias supplies, no blower, only one tuned circuit.

SERVICE OF OPERATION

The condition is met, but it has already been observed that higher peak powers are available during low duty cycle voice waveforms without speech processing. So for this amplifier and power supply, there is some advantage in not using speech processing. A change to a regulated power supply would give a higher relative power during speech processing, but would limit the peak available power to 400 Watts by law.

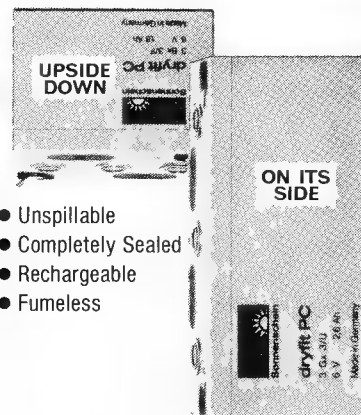
COST

The total cost was of the order of \$50 which must be considered low. The other part of cost, time, was fairly high. Several weeks of part-time fiddling and investigation were involved, the greater part being the work on the power transformer, and the various efforts on the band change switch.

On the other hand, there is a great deal to be learned from a project such as this. Not so much the process of the construction, but the exercise of solving problems for one's self from a combined theoretical/practical point of view. At the end of it all there is the satisfaction of saying over the air . . . "An FT101E into a HOMEBREW linear running the legal limit". ■

R.H. Cunningham
Pty. Ltd.

This lead acid battery can be fitted in any position . . .



- Unspillable
- Completely Sealed
- Rechargeable
- Fumeless

Sonnenschein batteries are of the lead-acid type, ideal for all kinds of portable electronic equipment requiring 2, 6 or 12 volts at .9 to 7 amp hours capacity. Send for free comprehensive Technical Manual.



Sonnenschein

**Sonnenschein
dryfit PC
BATTERIES**
For the man who has
a battery problem.

Available from Wholesalers
or the Australian Agents

R.H. Cunningham
Pty. Ltd.

VIC.: 493-499 Victoria St., West
Melbourne, 3003 Ph.: 329 9633
N.S.W.: 4-8 Waters Rd., Neutral
Bay, 2089. Ph.: 909 2388
W.A.: 256 Stirling St., Perth,
6000 Ph. 28 3655
QLD.: L. E. BOUGHEN & CO.,
30 Grimes St., Auchenflower,
4066. Ph.: 370 8097
S.A.: Werner Electronic
Industries Pty. Ltd., Unit 25,
6-8 Gray St., Kilkenny, 5009.
Ph. 268 2801.

Telex: Melbourne, 31447
Sydney, 21707. Brisbane,
41500. Perth, 93244.